DESCRIPTION

HEAT EXCHANGER AND PROCESS FOR FABRICATING SAME

CROSS REFERENCE TO RELATED APPLICATION

This application is an application filed under 35 U.S.C. §111(a) claiming the benefit pursuant to 35 U.S.C. §119(e)(1) of the filing date of Provisional Application No. 60/532,905 filed December 30, 2003 pursuant to 35 U.S.C. §111(b).

TECHNICAL FIELD

The present invention relates to heat exchangers for use as oil coolers, aftercoolers, radiators or the like for industrial machines such as compressors, tool machines and hydraulic machines, and also to a process for fabricating the same.

The upper and lower sides and the left- and right-hand sides of FIG. 1 will herein and in the appended claims be referred to as "upper," "lower," "left" and "right," respectively. The downstream side with respect to the direction in which a fluid flows through each adjacent pair of flat hollow bodies so to be subjected to heat exchange with a fluid flowing through the hollow bodies, i.e., the direction indicated by the arrow X in FIGS. 1 and 8, will be referred to as "front," and the opposite side as "rear." These terms "upper," "lower," "left," "right," "front" and "rear" are thus defined for the sake of convenience, and the terms in each pair may be used as interchanged by each other. Further in the following

description, the term "aluminum" includes aluminum alloys in addition to pure aluminum.

BACKGROUND ART

The heat exchangers for use in industrial machines as oil coolers, aftercoolers, radiators, etc. include those which comprise a plurality of flat hollow aluminum bodies arranged one above another in parallel at a spacing and extending in a left-right direction for passing a fluid of high temperature therethrough, two aluminum communication members arranged respectively between the left and right end portions of each adjacent pair of flat hollow bodies and brazed to the adjacent hollow bodies, the adjacent hollow bodies being held in communication with each other through the communication members, and a corrugated aluminum fin disposed between and brazed to each adjacent pair of flat hollow bodies and positioned between the left and right communication members. Each of the flat hollow bodies comprises an upper and a lower flat wall and a peripheral wall interconnecting the peripheral edges of the upper and lower walls, each of the upper and lower walls of each flat hollow body having one through hole formed in each of left and right end portions thereof、each of the left and right communication members having one through hole communicating with the corresponding through holes of the upper and lower walls of the hollow body, the left and right end portions of the flat hollow bodies and the left and right communication members respectively providing a pair of left and right headers extending vertically (see, for example, the

publication of JP-A No. 2001-82891 and the publication of No. 8-233476).

The flat hollow body comprises two flat plates arranged one above the other at a spacing and each made of an aluminum brazing sheet having a brazing material layer over each of opposite surfaces thereof, and an aluminum channel forming body interposed between and brazed to the two flat plates, each of the flat plates having a through hole formed in each of left and right end portions thereof, the channel forming body comprising a peripheral wall interconnecting the peripheral edges of the two flat plates, and a heat transfer area increasing portion interconnecting longitudinal intermediate parts of two straight portions of the peripheral wall which are positioned respectively at the front and rear opposite side edges of the flat plates.

However, the conventional heat exchanger has the following problems. The two communication members arranged respectively between the left and right end portions of each adjacent pair of flat hollow bodies give relatively great weight to the heat exchanger in its entirety. Since the communication member must have a communication hole for passing a fluid of high temperature and high pressure therethrough, the portion of the communication member surrounding the through hole needs to have an increased wall thickness, consequently increasing the weight of the communication member and therefore giving increased weight to the entire heat exchanger. The pair of headers, which are provided respectively at the left and right sides of the exchanger, give a relatively small area to the

portion of heat exchange between the fluid of high temperature and a fluid of low temperature, i.e., to the so-called heat exchange core, relative to the required overall size of the heat exchanger to be installed, posing a limitation on the improvement of heat exchange efficiency. The fluid of high temperature flows into one of the headers, then flows through the flat hollow bodies into the other header. During this time, the fluid is subjected to heat exchange with the fluid of low temperature flowing forward from the rear through the clearances between the respective adjacent pairs of hollow bodies. The high-temperature fluid portion flowing through the rear side portions of the hollow bodies is efficiently cooled in this case, but the low-temperature fluid portion reaching the front side portions of the clearances between the hollow bodies has its temperature raised to a relatively high level, so that the high-temperature fluid portion flowing through the front side portions of the interior of the hollow bodies is cooled less effectively. Thus, the overall heat exchange performance still remains to be improved.

Accordingly, the present applicant has previously proposed a heat exchanger which has overcome these problems. The proposed heat exchanger comprises a plurality of flat hollow bodies arranged one above another in parallel at a spacing and extending in a left-right direction, a communication member disposed between left end portions of each adjacent pair of flat hollow bodies for holding the adjacent pair of flat hollow bodies in communication with each other therethrough, a spacer bar disposed between the right end portions of each adjacent pair

of flat hollow bodies, each of the flat hollow bodies comprises an upper and a lower flat wall elongated in the left-right direction, a peripheral wall interconnecting the upper and lower walls at the peripheral edges thereof, and a partition wall dividing the interior of the hollow body into two straight channels extending in the left-right direction, a left end portion of each of the upper and lower walls being provided respectively at front and rear areas thereof on opposite sides of the partition wall with two through holes spaced apart in a front-rear direction for causing the respective channels to communicate with the communication member therethrough, the partition wall having a right end portion cut off to hold the two channels in communication with each other therethrough, the spacer bar having a left-to-right width considerably smaller than the left-to-right length of a cutoff left end portion of the partition wall of the flat hollow body (see the publication of JP-A No. 2004-184057).

In the heat exchanger disclosed in the publication of JP-A No. 2004-184057, each of the flat hollow bodies comprises upper and lower two flat plates elongated in the left-right direction and arranged one above the other at a spacing, and a channel forming body disposed between and brazed to the two flat plates, the channel forming body comprising two straight side bars arranged between the upper and lower flat plates respectively at the front and rear side edges thereof and extending in the left-right direction, an intermediate bar positioned between and spaced from the two side bars and extending in the left-right direction, two heat transfer area increasing

portions formed between the intermediate bar and the respective side bars integrally therewith and provided at an intermediate portion of the height of the bars, and two end bars extending forwardly or rearwardly inward respectively from the left ends of the side bars integral therewith and having inner ends bearing on and brazed to the left end of the intermediate bar respectively at the front and rear side faces thereof, the intermediate bar having a cutoff right end portion, the two heat transfer area increasing portions each having a cutoff left end portion, the left end portion of each of the upper and lower flat plates having two through holes formed respectively in front and rear areas thereof on opposite sides of the intermediate bar, the upper and lower flat plates providing the upper and lower walls respectively, the upper and lower flat plates having respective right end portions each bent toward the other, the bent end portions being lapped over and brazed to each other to provide a right wall portion of the peripheral wall, the two side bars of the channel forming body providing front and rear side wall portions of the peripheral wall, the end bars of the channel forming body providing a left wall portion of the peripheral wall, the intermediate bar of the channel forming body providing the partition wall.

The present inventor has conducted extensive research and found that the proposed heat exchanger is likely to have the following problem. At the portion of the channel forming body where the intermediate bar is cut off, the upper and lower flat plates are brazed only to the side bars, so that the flat plates have a reduced strength this portion. When the fluid

flowing inside the flat hollow body has a high pressure, the plates are likely to bulge or develop other trouble although the fluid gives rise to no problem when having a low pressure.

An object of the present invention is to overcome the above problems and to provide a heat exchanger wherein a fluid of high pressure can be passed through flat hollow bodies.

DISCLOSURE OF THE INVENTION

To fulfill the above object, the present invention comprises the following modes.

1) A heat exchanger comprising a plurality of flat hollow bodies arranged one above another in parallel at a spacing and extending in a left-right direction, a communication member disposed between left end portions of each adjacent pair of flat hollow bodies for holding the adjacent pair of flat hollow bodies in communication with each other therethrough, a spacer in the form of a block and disposed between right end portions of each adjacent pair of flat hollow bodies, each of the flat hollow bodies comprises an upper and a lower flat wall elongated in the left-right direction, a peripheral wall interconnecting the upper and lower walls at peripheral edges thereof, and a partition wall dividing interior of the hollow body into two straight channels extending in the left-right direction, a left end portion of each of the upper and lower walls being provided respectively at front and rear areas thereof on opposite sides of the partition wall with two through holes spaced apart in a front-rear direction for causing the

respective channels to communicate with the communication member therethrough, the partition wall having a right end portion cut off to hold the two channels in communication with each other therethrough, the spacer being provided with a bore extending therethrough in the front-rear direction, the spacer being positioned in corresponding relation with the cutoff portion of the partition wall of the flat hollow body.

2) A heat exchanger according to par. 1) wherein the spacer has a left-to-right width larger than the length of the cutoff portion of the partition wall in the left-right direction.

3) A heat exchanger according to par. 1) wherein the spacer has a plurality of bores extending therethrough in the front-rear direction and arranged side by side in the left-right direction.

4) A heat exchanger according to par. 1) wherein the spacer has an inner peripheral surface defining the bore and provided with a plurality of ridges and/or furrows extending longitudinally of the bore.

5) A heat exchanger according to par. 1) wherein each of the flat hollow bodies comprises upper and lower two flat plates elongated in the left-right direction and arranged one above the other at a spacing, and a channel forming body disposed between and brazed to the two flat plates, the channel forming body comprising two straight side bars arranged between the upper and lower flat plates respectively at front and rear side edges thereof and extending in the left-right direction, an intermediate bar positioned between and spaced from the

two side bars and extending in the left-right direction, two heat transfer area increasing portions formed between the intermediate bar and the respective side bars integrally therewith and provided at an intermediate portion of the height of the bars, and two end bars extending forwardly or rearwardly inward respectively from left ends of the side bars integral therewith and having inner ends bearing on and brazed to a left end of the intermediate bar respectively at front and rear side faces thereof, the intermediate bar having a cutoff right end portion, the two heat transfer area increasing portions each having a cutoff left end portion, a left end portion of each of the upper and lower flat plates having two through holes formed respectively in front and rear areas thereof on opposite sides of the intermediate bar, the upper and lower flat plates providing the upper and lower walls respectively, the upper and lower flat plates having respective right end portions each bent toward the other, the bent end portions being lapped over and brazed to each other to provide a right wall portion of the peripheral wall, the two side bars of the channel forming body providing front and rear side wall portions of the peripheral wall, the end bars of the channel forming body providing a left wall portion of the peripheral wall.

6) A heat exchanger according to par. 5) wherein the upper and lower flat plates are each made of an aluminum brazing sheet, and a channel forming body comprises an aluminum extrudate.

7) An industrial machine comprising a heat exchanger according to any one of par. 1) to 6) and serving as an oil

cooler.

8) An industrial machine comprising a heat exchanger according to any one of par. 1) to 6) and serving as an aftercooler.

9) A process for fabricating a heat exchanger according to par. 1) which is characterized by: preparing channel forming blanks each comprising two straight side bars arranged as spaced apart in the front-rear direction and extending in the left-right direction, an intermediate bar positioned between and spaced from the two side bars and extending in the left-right direction, and two flat plate portions formed between the intermediate bar and the respective side bars integrally therewith and provided at an intermediate portion of the height of the bars, pairs of upper and lower flat plates elongated in the left-right direction, communication members each having two through bores spaced apart in the front-rear direction and extending vertically, and spacers each having a bore extending therethrough in the front-rear direction; making channel forming bodies from the respective blanks each by cutting off left and right opposite end portions of the intermediate bar of the blank, cutting off a left end portion of each of the flat plate portions of the blank over a length larger than the cutoff length of the left end portion of the intermediate bar, subjecting the two flat plate portions of the blank to press work to make heat transfer area increasing portions, and bending left end portions of the side bars of the blank leftwardly or rightwardly inward to cause inner ends of the side bars to bear respectively on front and rear side faces of the intermediate bar to form end

bars; bending right end portions of each pair of upper and lower flat plates toward each other to form bent portions and forming two through holes in a left end portion of each flat plate in areas thereof to be positioned on front and rear opposite sides of the intermediate bar; making a plurality of combinations each comprising the resulting pair of upper and lower flat plates and the channel forming body disposed therebetween, arranging the combinations one above another in parallel at a spacing, providing each of the communication members between left end portions of each adjacent pair of combinations so as to permit the two through bores to communicate with the respective through holes of each flat plate, providing each of the spacers between right end portions of each adjacent pair of combinations, and further positioning a fin between each adjacent pair of combinations between the communication member and the spacer; and brazing each pair of upper and lower flat plates to the side bars, the intermediate bar and the end bars of the channel forming body between the pair of plates, the inner ends of the end bars to the intermediate bar, and the bent portions of each pair of flat plates to each other, and further brazing each flat plate to the communication member, the spacer and the fin which are adjacent thereto.

10) A process for fabricating a heat exchanger according to par. 9) wherein each of the flat plates is made of an aluminum brazing sheet, and each of the communication members, the spacers and the channel forming blanks is made of an aluminum extrudate, the fin being made from a thin aluminum plate, the brazing being performed with a brazing material released from the flat

plates on melting.

11) A process for fabricating a heat exchanger according to par. 9) wherein the spacers have a left-to-right width larger than the cutoff length of the right end portion of the intermediate bar of the channel forming blank in the left-right direction.

12) A process for fabricating a heat exchanger according to par. 9) wherein each of the spacers has a plurality of bores extending therethrough in the front-rear direction.

13) A process for fabricating a heat exchanger according to par. 9) wherein each of the spacers has an inner peripheral surface defining the bore and provided with a plurality of ridges and/or furrows extending longitudinally of the bore.

With the heat exchanger described in par. 1), the spacer is positioned in corresponding relation with the cutoff portion of the partition wall of the flat hollow body, so that the upper and lower walls are prevented from becoming lower in strength even at the portion of the flat hollow body where no partition wall portion exits for interconnecting the upper and lower walls. Consequently, the upper and lower walls are prevented from bulging even when a fluid of high pressure is passed inside the hollow body, and the fluid of high pressure can be passed through the hollow body. Additionally, the spacer can be smaller in weight than when the spacer has no bore extending therethrough, preventing the heat exchanger from increasing in weight in its entirety. A fluid for cooling the fluid of high temperature flowing inside the flat hollow bodies of the heat exchange unit, for example, cold air, flows through the through bores of the spacers, with the result that the spacers

also contribute to heat exchange, consequently achieving a higher efficiency in refrigerating the fluid of high temperature flowing inside the hollow bodies than when spacers having no through bores are used.

With the heat exchanger according to par. 2), the width of the spacer is larger than the length of the partition wall cutoff portion of the hollow body with respect to the left-right direction. This reliably prevents the upper and lower walls from becoming impaired in strength at the portion of the flat hollow body where no partition wall portion exits for interconnecting the upper and lower walls, with the result that the upper and lower walls are reliably precluded from bulging or developing other trouble when a fluid of high pressure is passed inside the hollow body. The fluid of high pressure can therefore passed through the hollow body.

With the heat exchanger according to par. 3), the portion of the spacer between adjacent pair of bores serves to reinforce the upper and lower walls of the flat hollow body. The upper and lower walls can therefore be prevented from becoming impaired in strength more reliably.

With the heat exchanger according to par. 4), the inner peripheral surface of the spacer defining the bore is provided with ridges and/or furrows extending longitudinally of the bore. This gives an increased area of heat transfer between the fluid of high temperature flowing inside the hollow body and a fluid of low temperature flowing through the bore, further improving the high-temperature fluid refrigeration efficiency mentioned above with reference to par. 1).

With the heat exchanger according to par. 5), the spacer is positioned in corresponding relation with the cutoff portion of the intermediate bar of the channel forming body which bar provides the partition wall of the hollow body, so that the upper and lower flat plates are prevented from becoming lower in strength even at the hollow body portion where there exists no intermediate bar brazed to these flat plates, and are consequently precluded, for example, from bulging even when a fluid of high pressure if passed inside the hollow body. The fluid of high pressure can therefore passed through the hollow bodies. With the inner ends of the end bars of the channel forming body brazed to the intermediate bar, the flat hollow body has an enhanced strength. Stated more specifically, the left end portion of the intermediate bar of the channel forming body is brazed to the upper and lower flat plates each at the portion thereof between the two through holes, and the inner ends of the end bars are brazed to this intermediate bar. Accordingly, the end bars are prevented from breaking even if subjected to a leftward force as exerted thereon by the fluid flowing inside the hollow body.

The heat exchanger according to par. 6) is reduced in weight in its entirety and is easy to fabricate.

Heat exchangers having the advantages described with reference to par. 1) can be fabricated easily by the process according to par. 9).

Heat exchangers can be fabricated with greater ease and can be further reduced in weight when fabricated by the process described in par. 10).

Heat exchangers having the advantage described with reference to par. 2) can be fabricated easily by the process according to par. 11).

Heat exchangers having the advantage described with reference to par. 3) can be fabricated easily by the process according to par. 12).

Heat exchangers having the advantage described with reference to par. 4) can be fabricated easily by the process according to par. 13).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view showing the overall construction of an oil cooler to which a heat exchanger of the invention is applied. FIG. 2 is an exploded perspective view showing a portion of the oil cooler. FIG. 3 is a perspective view partly broken away and showing a flat hollow body of the oil cooler, with a heat transfer area increasing portion omitted. FIG. 4 is a view in vertical section showing the right end portion of the flat hollow body of the oil cooler on an enlarged scale. FIG. 5 is a fragmentary perspective view of the left end portion of channel forming body of the hollow body to show a process for making the channel forming portion. FIG. 6 is a fragmentary perspective view of the right end portion of the channel forming body of the hollow body to show the process. FIG. 7 is an exploded perspective view showing the lower end portion of the oil cooler. FIG. 8 is a diagram showing how an oil flows through the oil cooler. FIG. 9 is a perspective view of a modification of a spacer.

BEST MODE OF CARRYING OUT THE INVENTION

An embodiment of the present invention will be described below with reference to the drawings.

FIG. 1 show the overall construction of a heat exchanger of the invention, and FIGS. 2 to 4 and 7 show the constructions of main portions thereof. FIGS. 5 and 6 shows a process for making a channel forming body of a flat hollow body, and FIG. 8 shows the flow of a fluid of high temperature through the heat exchanger. Throughout the drawings, like parts will be designated by like reference numerals.

The present embodiment is an oil cooler for compressors to which a heat exchanger of the invention is applied. Examples of such compressors are load compressors, compressors for use in gas turbines, compressors useful for brakes of railroad vehicles, etc.

FIG. 1 shows an oil cooler 1 which comprises flat hollow aluminum bodies 2 arranged one above another in parallel at a spacing and extending in a left-right direction, i.e., laterally of the cooler 1, for passing an oil of high temperature therethrough, a communication member 3 made of an aluminum extrudate, disposed between the left end portions of each vertically adjacent pair of flat hollow bodies 2 and brazed to the adjacent pair of flat hollow bodies 2 for holding the hollow bodies in communication with each other therethrough, a spacer 4 made of an aluminum extrudate, disposed between the right end portions of each adjacent pair of flat hollow bodies 2 and brazed to the adjacent pair of flat hollow bodies 2, and a corrugated aluminum fin 6 disposed between the

communication member 3 and the spacer 4 in an air passing clearance 5 between each adjacent pair of flat hollow bodies 2 and brazed to the pair adjacent pair of flat hollow bodies 2.

An inlet-outlet member 7 made of an aluminum extrudate and having the same thickness and size as the communication member 3 is disposed under the left end portion of the flat hollow body 2 at the lower end of the oil cooler and brazed to the end hollow body 2. A spacer 4 the same as the spacer 4 between the flat hollow bodies 2 is similarly disposed under the right end portion of the end hollow body 2 and brazed to the body 2. A lower side plate 8 elongated laterally of the cooler 1 has a left end portion brazed to the right end portion of the lower surface of the inlet-outlet member 7 and a right end portion brazed to the entire lower surface of the spacer 4. The space between the lower side plate 8 and the end hollow body 2 also serves as an air passing clearance 5, which is provided with a corrugated fin 6, the fin being brazed to the lower side plate 8 and the end hollow body 2. The lower side plate 8 comprises an aluminum brazing sheet having a brazing material layer over the upper surface thereof.

A communication member 3 the same as the communication member 3 between the flat hollow bodies 2 is provided on the upper side of the left end portion of the flat hollow body 2 at the upper end of the oil cooler 1 and brazed to the upper end hollow body 2. A spacer 4 the same as the spacer 4 between the flat hollow bodies 2 is similarly disposed on the upper side of the right end portion of the upper end hollow body

2 and brazed to the body 2. An upper side plate 9 elongated laterally of the cooler 1 has a left end portion brazed to the entire upper surface of the communication member 3 and a right end portion brazed to the entire upper surface of the spacer 4. The space between the upper side plate 9 and the upper end hollow body 2 also serves as an air passing clearance 5, which is provided with a corrugated fin 6. The fin 6 is brazed to the upper side plate 9 and the upper end hollow body 2. The upper side plate 9 comprises an aluminum brazing sheet having a brazing material layer over the upper surface thereof.

With reference to FIGS. 2 and 3, the flat hollow body 2 comprises an upper and a lower wall 11 elongated laterally of the cooler 1, a peripheral wall 12 interconnecting the upper and lower walls 11 at their peripheral edges, and a partition wall 15 dividing the interior of the hollow body 2 into front and rear two channels 13, 14 extending laterally of the cooler. The left end portion of each of the upper and lower walls 11 is provided, respectively at the front and rear areas thereof on opposite sides of the partition wall 15, with two through holes 16, 17 spaced apart in the front-rear direction for causing the respective channels 13, 14 to communicate with the outside therethrough. The partition wall 15 has a right end portion cut off to hold the two channels 13, 14 in communication with each other therethrough. The communication portion is indicated at 18. The flat hollow body 2 comprises two rectangular flat plates 19, 21 made of an aluminum brazing sheet having a brazing material layer over opposite surfaces thereof, elongated laterally of the cooler and vertically spaced

apart, and a channel forming body 22 made of an aluminum extrudate and disposed between and brazed to the upper and lower flat plates 19, 21.

The through holes 16, 17 are formed respectively in the front and rear areas of left end portion of each of the flat plates 19, 21. The two flat plates 19, 20 have respective right end portions which are bent toward each other. Stated more specifically, the upper flat plate 19 has its right end portion bent downward, while the lower flat plate 21 has its right end portion bent upward to provide bent portions 19a, 21a which are lapped over and brazed to each other (see FIG. 4). The two flat plates 19, 21 provide the upper and lower walls 11, and the bent portions 19a, 21a of the two flat plates 19, 21 provide a right wall portion 12a of the peripheral wall 12.

The channel forming body 22 comprises two straight side bars 23 arranged between the upper and lower flat plates 19, 21 respectively at their front and rear side edges and extending laterally of the cooler 1, an intermediate bar 24 positioned between and spaced from the two side bars 23 and extending laterally of the cooler 1, two heat transfer area increasing portions 25 formed between the intermediate bar 24 and the respective side bars 23 integrally therewith and provided at an intermediate portion of the height of the bars, and two end bars 26 extending forwardly or rearwardly inward from the left ends of the respective side bars 23 integral therewith and having inner ends bearing on and brazed to the left end of the intermediate bar 24 respectively at the front and rear

side faces thereof. The two side bars 23, intermediate bar 24 and two end bars 26 are brazed to the upper and lower flat plates 19, 21. The intermediate bar 24 has a left end portion brazed to the two flat plates 19, 21 at the portions thereof between the two through holes 16, 17. The intermediate bar 24 has a right end portion cut out over a predetermined length to provide the communication portion 18. The two heat transfer area increasing portions 25 have left end portions which are cut out over a specified length so as to provide through holes in register with the respective through holes 16, 17 in the flat plates 19, 21. The side bars 23 of the channel forming body 22 provide front and rear side wall portions 12b of the peripheral wall 12, and the two end bars 26 of the body 22 provide a left wall portion 12c of the peripheral wall 12.

With reference to FIG. 4, the heat transfer area increasing portion 25 comprises a plurality of wavy strips 27 each comprising upward bent portions 27a and downward bent portions 27b which are arranged alternately laterally of the portion 25 and interconnected by horizontal portions 27c, the wavy strips 27 being arranged in the front-rear direction and interconnected by the horizontal portions 27c into an integral piece. In each adjacent pair of wavy strips 27 of the portion 25, the upward bent portions 27a of one of the wavy strips are displaced from those 27a of the other strip laterally of the portion 25, and the downward bent portions 27b of one of the wavy strips are displaced from those 27b of the other strip with respect to the lateral direction. With each wavy strip 27 of the heat transfer area increasing portion 25, there is the horizontal

portion 27c between each laterally adjacent pair of upward bent portion 27a and downward bent portion 27b, and each forwardly or rearwardly adjacent pair of wavy strips 27 are joined to each other at horizontal portions 27c, whereas the horizontal portions 27c need not always be provided. In each adjacent pair of wavy strips 27, at the part where the upward bent portion 27a extends into the downward bent portion 27b in one of the strip extends across like part of the other strip, so that the two strips are joined together at such parts.

The channel forming body 22 is made in the manner shown in FIGS. 5 and 6. Channel forming blanks 29 each in the form of an aluminum extrudate are made, each of the blanks 29 comprising two straight side bars 23 arranged as spaced apart in the front-rear direction and extending in the left-right direction, an intermediate bar 24 positioned between and spaced from the two side bars 23 and extending in the left-right direction, and two flat plate portions 28 formed between the intermediate bar 24 and the respective side bars 23 integrally therewith and provided at an intermediate portion of the height of the bars [see FIG. 5(a) and FIG. 6(a)]. Left and right opposite end portions of the intermediate bar 24 of each blank 29 are then cut off over a specified length, and a left end portion of each of the two flat plate portions 28 of the blank is cut out over a length larger than the cutoff length of the left end portion of the intermediate bar 24 [see FIG. 5(b) and FIG. 6(b)]. The two flat plate portions 28 of the blank are subsequently subjected to press work to make heat transfer area increasing portions 25 [see FIG. 5(c) and FIG. 6(c)].

The left end portions of the side bars 23 of the blank are thereafter bent leftwardly or rightwardly inward to cause the inner ends of the side bars 23 to bear respectively on the front and rear side faces of the intermediate bar 24 [See FIG. 5(d)] and braze the inner ends to the intermediate bar 24, whereby two end bars 26 are formed. In this way, the channel forming body 22 is made. The inner ends of the end bars 26 are brazed to the intermediate bar 24 with the molten brazing material released from the flat plates 19, 21 on melting when a unit-type heat exchanger 1 is fabricated in the manner to be described later.

As shown in FIG. 2, each communication member 3 has front and rear two vertical through bores 31, 32 to be positioned in register with the respective two through holes 16, 17 of the upper and lower walls 11 of the flat hollow body 2 when seen from above so as to communicate with these holes 16, 17. The front side portions of the front end portions of all flat hollow bodies 2 and the front side portions of all communication members 3 provide an inlet header 33A (see FIG. 8). In the inlet header 33A, the left end portions of the front channels 13 of all flat hollow bodies 2 are caused to communicate with the front vertical through bores 31 of all communication members 3 through the front through holes 16 of the upper and lower walls 11. The rear side portions of the rear end portions of all flat hollow bodies 2 and the rear side portions of all communication members 3 provide an outlet header 33B (see FIG. 8). In the outlet header 33B, the left end portions of the rear channels 14 of all flat hollow bodies 2 are caused to

communicate with the rear vertical through bores 32 of all communication members 3 through the rear through holes 17 of the upper and lower walls 11.

The two vertical through bores 31, 32 of the communication member 3 disposed on the upper side of the left end portion of the flat hollow body 2 at the upper end of the oil cooler 1 have their upper-end openings closed by the upper side plate 9.

With reference to FIG. 7, the portion of the inlet-outlet member 7 leftwardly of the left end of the lower side plate 8 has front and rear two vertical through bores 34, 35 communicating with the respective through holes 16, 17 of the lower wall 11 of the flat hollow body at the lower end of the cooler 1. These through bores 34, 35 have internally threaded inner peripheries 34a, 35a.

As shown in FIG. 2, the spacer 4 has a lateral width larger than the length of the cutoff portion of the intermediate bar 24 of the channel forming body 22, i.e., the lateral length of the communication portion 18. The spacer 4 further has a plurality of bores 36 extending therethrough in the front-rear direction and arranged side by side in the lateral direction.

The oil cooler 1 is fabricated by making combinations each comprising a pair of flat plates 19, 21 of aluminum brazing sheet and a channel forming body 22 positioned therebetween, arranging the combinations one above another in parallel at a spacing, providing a communication member 3 between left end portions of each adjacent pair of combinations so as to permit the two through bores 31, 32 to communicate with the

respective through holes 16, 17 of the flat plates 19, 21, providing a spacer 4 between right end portions of each adjacent pair of combinations, and further positioning a corrugated fin 6 between each adjacent pair of combinations between the communication member 3 and the spacer 4, arranging an inlet-outlet member 7, spacer 4, corrugated fin 6 and lower side plate 8 under the combination at the lower end of the resulting assembly, arranging a communication member 3, spacer 4, corrugated fin 6 and upper side plate 9 on the upper side of the combination at the upper end of the assembly, tacking the resulting assembly by suitable means, and collectively brazing the assembly. At this time, the end bars 26 of each channel forming body 22 are brazed to the intermediate bar 24 thereof with the molten brazing material released from the flat plates 19, 21 on melting.

With the oil cooler 1 described above, oil of high temperature flows into the inlet header 33A through the front vertical through bore 34 of the inlet-outlet member 7 as indicated by the arrow Y in FIG. 8, then dividedly flows into all the flat hollow bodies 2 to flow rightward through the front channels 13 thereof, further flows into the rear channels 14 via the communication portions 18, then flows leftward through the rear channels 14 into the outlet header 33B and flows out through the rear vertical through bore 35 of the inlet-outlet member 7. While flowing through the front channels 13 and the rear channels 14 of all the flat hollow bodies 2, the oil is subjected to heat exchange with the cold air having a low temperature and flowing forward (see the arrow X) through the air passing

clearances 5. At this time, the oil is cooled also by the spacers 4, whereby an improved refrigeration efficiency is achieved.

In the case where the oil flowing inside the flat hollow bodies 2 has a high pressure, the upper and lower walls 11 of the hollow bodies 2, i.e., the portions of the upper and lower flat plates 19, 21 which are not brazed to the intermediate bar 24 adjacent thereto, namely, the portions of the plates 19, 21 which correspond to the communication portions 18, will be subjected to a great outward force, whereas such a force is received by the spacers 4, which prevent the upper and lower walls 11, i.e., the upper and lower flat plates 19, 21, from bulging outward.

In the foregoing embodiment, the inner peripheral surfaces of the spacer 4 defining the bores 36 extending therethrough may have a plurality of ridges 40 extending in the front-rear direction as shown in FIG. 9. These ridges 40 give an increased area of heat transfer from the spacer 4 to the cold air stream to achieve a further improved refrigeration efficiency. In place of the ridges 40 or in addition to the ridges 40, a plurality of furrows extending in the front-rear direction may be formed in the inner peripheral surfaces defining the bores 36.

In the above embodiment, the lateral width of the spacer 4 is greater than the lateral length of the cutoff portion of the intermediate bar 24 of the channel forming body 22, i.e., the lateral length of the communication portion 18, whereas this is not limitative; the lateral width of the spacer 4 may be smaller than the lateral length of the communication

portion 18. For example, even if the lateral width of the spacer 4 is smaller than the lateral length of the communication portion 18 by an amount corresponding to the lateral width of the upward or downward bent portion 27a or 27b of the wavy strip 27 of the channel forming body 22, the upper and lower walls 11, i.e., the upper and lower flat plates 19, 21, are prevented from bulging outward.

Although the heat exchanger of the present invention is embodied as an oil cooler for compressors according to the embodiment described above, this application is not limitative; the heat exchanger may be used as an aftercooler or a radiator for load compressors, gas turbine compressors, railroad vehicle compressors, etc. Furthermore, an aftercooler or radiator of suitable construction may be assembled into a unit along with the oil cooler which comprises a heat exchanger of the invention.

The heat exchanger of the present invention may be used as an oil cooler for cooling oils for use in tool machines or in hydraulic devices for cranes as used singly, or for deck cranes, truck cranes, power shovels or the like.

INDUSTRIAL APPLICABILITY

The present invention provides a heat exchanger, for example, for use as an oil cooler, aftercooler, radiator or the like for industrial machines such as compressors, tool machines and hydraulic devices